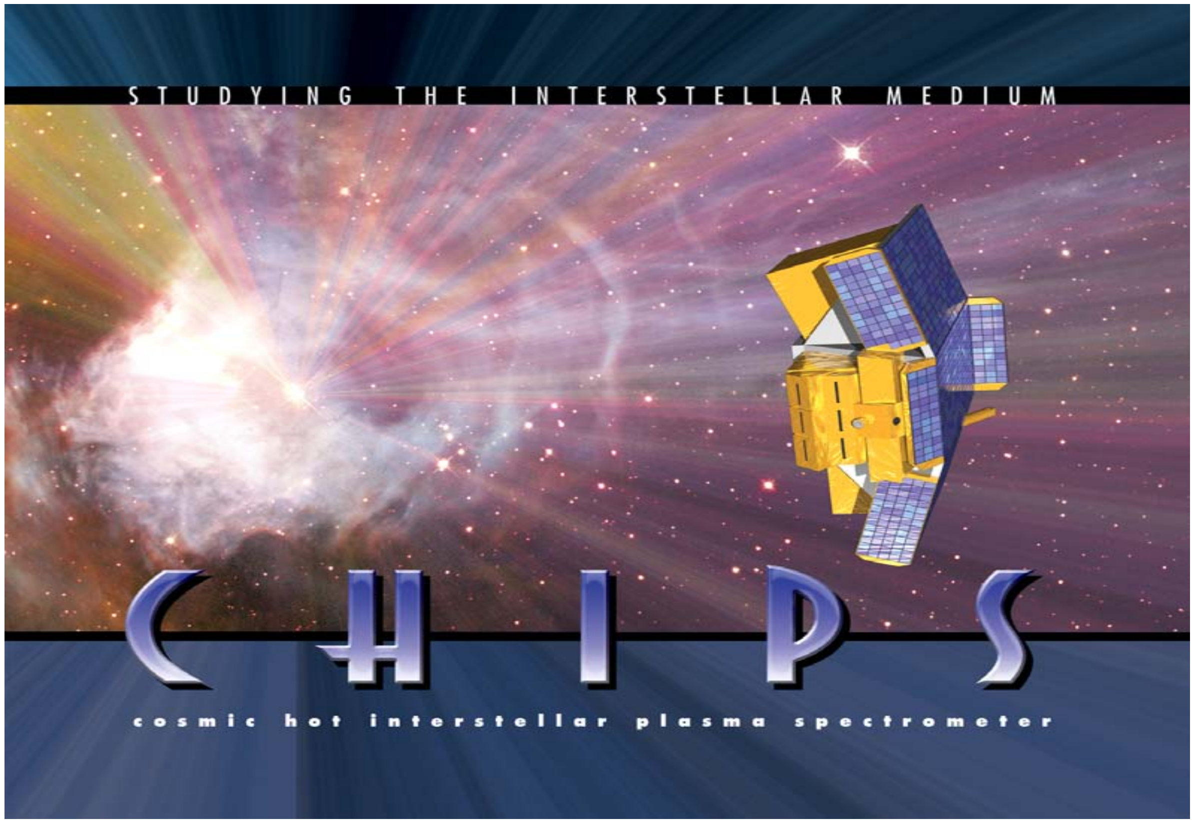
CHIPS/UNEX Lessons Learned



Mark Hurwitz/UCB
Ellen Riddle-Taylor/UCB
Mike Sholl/UCB
David Pierce/GSFC

September 30, 2003
Explorers Retreat

CHIPS/UNEX Lessons Learned

NASA/GSFC
UNEX Missions

- OVERVIEW OF UNEX AO
- CHIPS LESSONS LEARNED
- UNEX LESSONS LEARNED

Explorer Program Objectives

- Accomplish frequent, high quality space science investigations utilizing innovative, streamlined, and efficient management approaches.
- Reduce cost and improve performance by selecting investigations for which investigators will commit to cost limits, control business and technical processes, and apply and transfer new technology.
- Enhance public awareness of, and appreciation for, space science and to incorporate educational and public outreach activities as integral parts of space science investigations.
- Assist NASA in achieving its goal for the participation of small disadvantaged businesses, women-owned small businesses, Historically Black Colleges and Universities, and Other Minority Universities in NASA procurements.
- Explorer program classes are characterized by the scope of the mission, based primarily on cost and secondarily on payload size and mass and launch vehicle capabilities.
- ***University-Class Explorers (UNEX)*** are Space Science investigations characterized by a definition, development, launch service, and mission operations and data analysis cost not to exceed $13 million (in Fiscal Year 1998 dollars) total cost to NASA.

NASA/GSFC
UNEX Missions

University Class Missions

- Project Management of GSFC University Class missions.
- Serve as a facilitator for the PI to assure Mission Success.
- Funding Administration, Coordinate Reviews.
- Advocacy for PI/Mission to GSFC and NASA HQ.
- Fiduciary Responsibility to NASA to ensure mission is achieved in compliance with committed cost, schedule, performance, reliability, and safety requirements.
- Provide agreed upon support as requested by the PI.

University Class Explorers (UNEX) Project

Space Science investigations characterized by a definition, development, launch service, and mission operations and data analysis cost not to exceed $13 million total cost to NASA.

Education and Outreach to precollege education and enhancement of public understanding of space science required.

Program committed to visible/meaningful participation of HBCUs/OMUs

Launch readiness date of no later than June 30, 2001.

UNEX AO(1998): **29 UNEX Mission Proposal / 6 Mission of Op Received**

- 15 ELVs, 2nd payloads
- 8 Balloons
- 6 Shuttle Attached Payloads and Freeflyers

- The Missions selected were from the following NASA science themes:
- CHIPS / U of Cal/Berkley -Structure and Evolution of the Universe.

IMEX /U of Minn. - The Sun-Earth Connection

Both Missions selected were rated Category 1, Low Risk missions as Secondary payloads to be launched on Russian ELV and USAF Titan IV

NASA's Explorer Program
University Class Explorers (UNEX) Project

(CHIPS) - Cosmic Hot Interstellar Plasma Spectrometer

The Cosmic Hot Interstellar Plasma Spectrometer (CHIPS) spacecraft will use an extreme ultraviolet spectrograph during its one-year mission to study the "Local Bubble," a tenuous cloud of hot gas surrounding our Solar System that extends about 300 light- years from the Sun. Scientists believe that the million-degree gas in this region is generated by supernovae and stellar winds from hot stars, but want to better understand the origins and cooling of this gas, and apply knowledge of these processes to the study of other galaxies beyond our Milky Way.

The Principal Investigator for CHIPS is Dr. Mark Hurwitz of the University of California, Berkeley. The Earth-orbiting mission will cost $9.8 million, including launch, and will be launched aboard a commercial Final Analysis Inc. Satellite (FAISAT) as a secondary payload on a Russian Cosmos rocket in mid-2001.

NASA Press Release, September 11, 1998

NASA/GSFC
UNEX Missions

CHIPS' Launch Saga

- UNEX press release was put out on the missions, surprised the White House & the Office of Space Transportation Policy (OSTP), an interagency team comprised of FAA, NASA, Commerce, US Trade reps., etc met to discuss issue.

- NASA tried to obtain an exception for QuickRide regarding the foreign launch restriction. QR sold as an exception to the policy, and CHIPS as an instrument flying on a commercial bus that happened to fly on a foreign launcher was outside the intent of the policy restriction. OSTP would not budge on Launch Policy.

- With their baseline plan gutted, the CHIPS team undertook a task of far greater scope: developing a *dedicated* small satellite and identifying a path to orbit aboard a U.S. launch vehicle. Code M designated CHIPS as a secondary payload and provided launch on a Delta-II/GPS launch.The scope of the project changed yet again when, in late 2001, growth in the GPS mass made that opportunity unavailable.

- On the verge of cancellation, NASA identified a launch opportunity for CHIPS with ICESat. But the interfaces, launch orientation, and the orbit were dramatically different from those for which the instrument and spacecraft had been designed.

CHIPS Mission Overview

- **Mission Design**
  - Orbit: Inclination 94^o; 600 km circular
  - Mission Lifetime: 1 year
  - Launch Vehicle: Delta II 7320, Secondary P/L with ICESat
  - Spacecraft: 3-Axis stabilized, three reaction wheels, +/-2^o accuracy
  - Mass: Observatory: 111 kg estimated; 35% margin (170 kg)
  - Power: Observatory requirement: 42 watts; 22% margin (52 watts)
  - Ground Segment: RHESSI GS, ITR GS,Adelaide, AUS., WFF(backup) 16 Mb/day data volume, 2 passes/day
  - Operations: Initially: MOC @ SpaceDev, SOC at UCB; later transitioned MOC to UCB
- **Operational Phases**
  - Launch & early operations: 30 days
  - Minimum science requirement: 7 months (estimated pre-launch)
  - Mission lifetime: 12 months, Design lifetime: 18 months

Project Overview

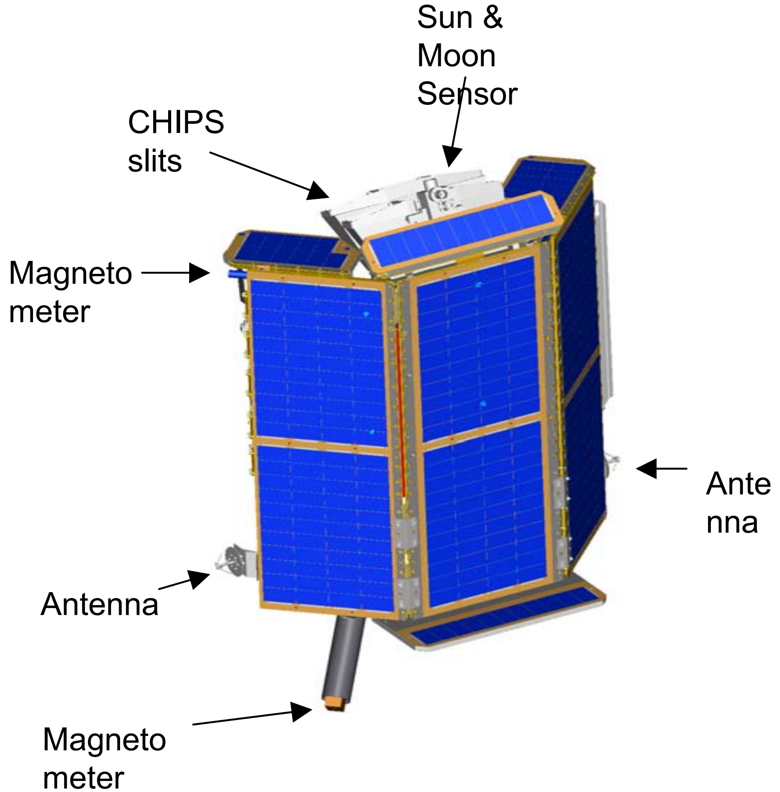
- First University-Class Explorer (UNEX)
  - Confirmed as low cost, “medium risk” mission judged under UNEX standards
  - Instrument fabricated at Space Sciences Lab, UCB
  - Spacecraft fabricated at SpaceDev, Inc., Poway, CA
    - Attitude control subcontracted to Dynacon Inc., Toronto
  - Largely single-string hardware, with targeted redundancy; extensive use of commercial parts in spacecraft

- Cost breakdown (real year dollars)
  - Funded by grant to U.C. Berkeley ($16M cost cap mission)
    - $14 M flight hardware
    - $2 M Phase E mission ops & data analysis
      - Separate $2 M LV integration provided by Code M

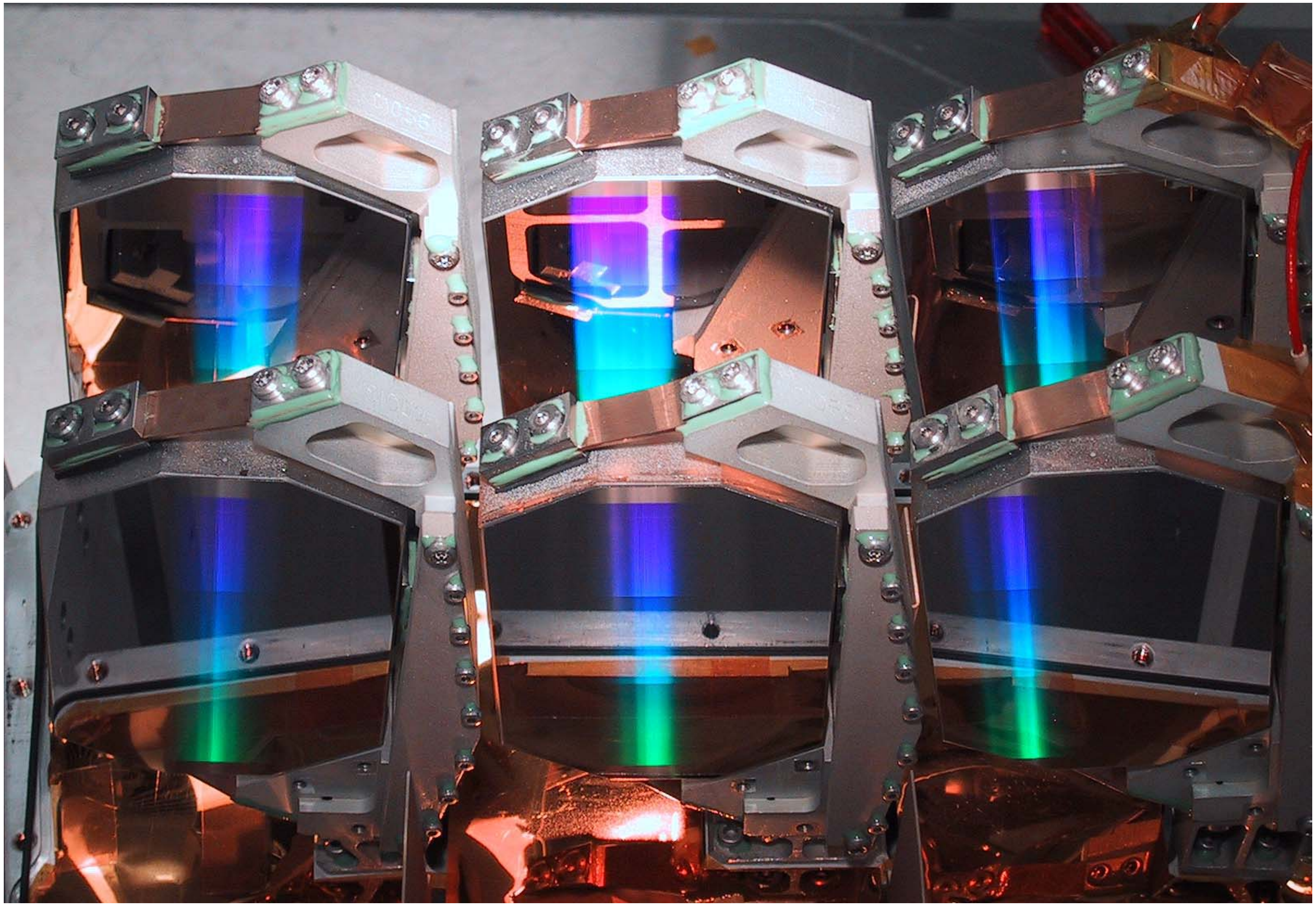
S/C Overview

Cosmic Hot Interstellar Plasma Spectrometer

- Solar Panels
  - Body Mounted, Aluminum honeycomb construction. Dual junction GaAs solar arrays. Power Positive in any configuration
- Batteries are sealed NiCd variant
  - 10-cell fiber-Ni-Cd battery 12V, 6.5Ah
- RF System is Sounding Rocket Tx/Rx (Emhiser)
- 3-axis stabilization
  - sun sensors, Magnetometer
  - Rate sensors, Lunar sensor
  - Reaction wheels, Torque coils
- Single-string, commercial parts; limited screening with targeted redundancy



CHIPS Diffraction Grating Array



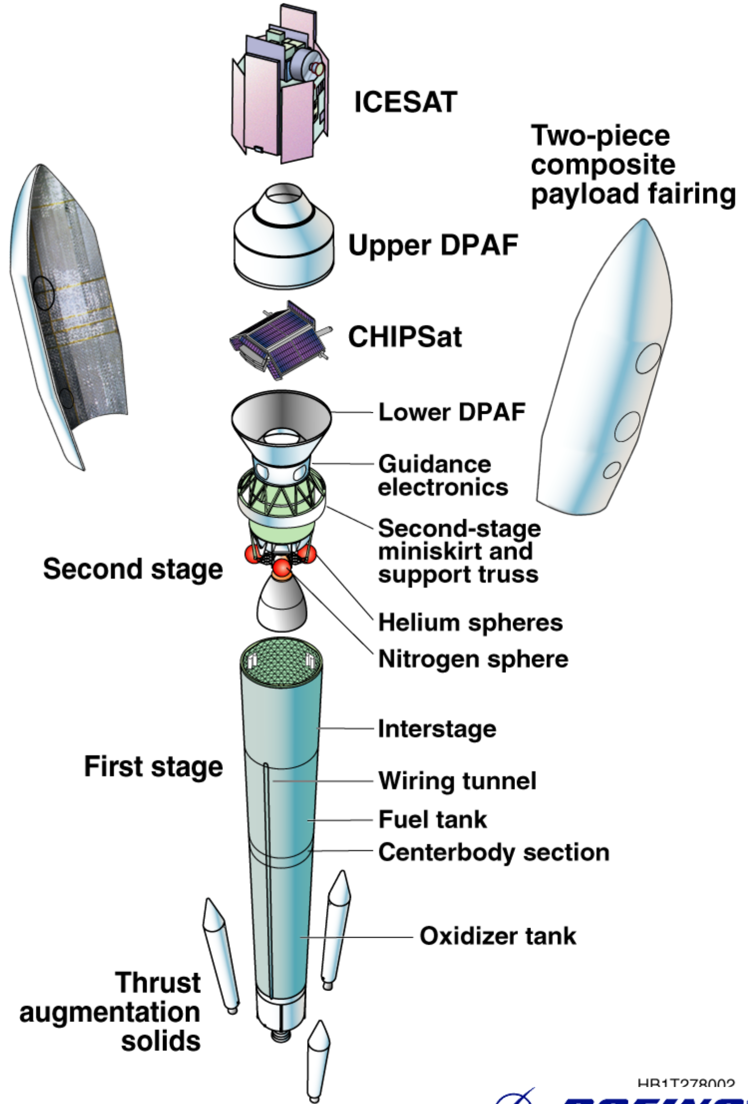
The six credit-card sized diffraction gratings of the CHIPS spectrograph

CHIPS – The Cosmic Hot Interstellar Plasma Spectrometer

NASA/GSFC
Explorer Program

ICESat/CHIPSat Configuration Requirements

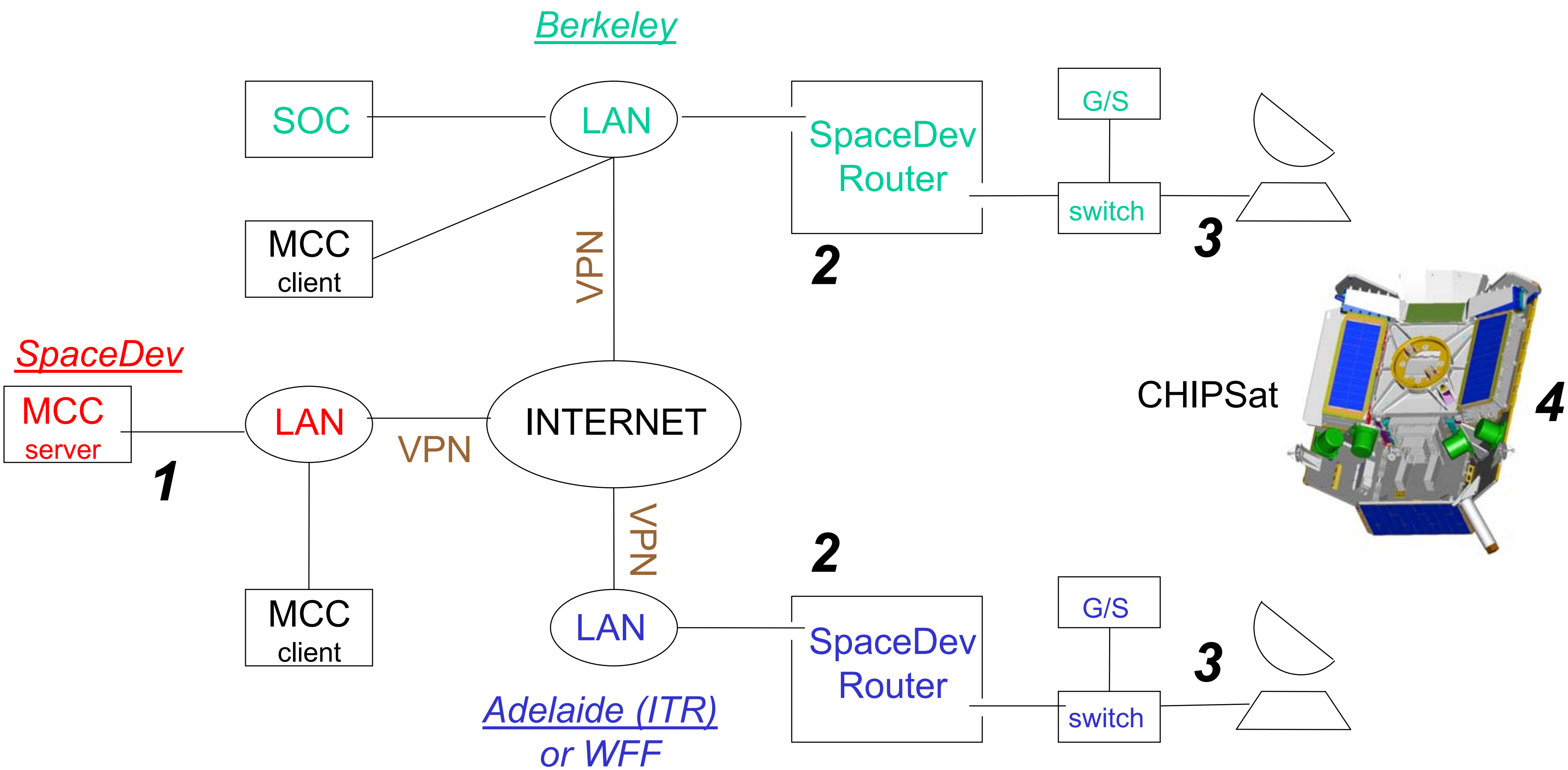
- Vehicle configuration: 7320-10C
- Launch site: SLC-2 at VAFB
- Launch date: 15 December 2002 (NET)
- Unique mission requirements
  - ^{3} 99.7% PCS
  - Reduced Height Dual payload attach fitting(RHDPAF)
  - Instrumentation (a la Jason/TIMED)
  - RHDPAF contamination barrier
  - BBQ roll (0.8 - 1.2dps)during coast phase
  - Remove 60-in^2 A/C vent door
  - Second-Stage dome foil and sidewall blankets due to PLF A/C from 55±5^0 F
  - Retro nozzles with 35-degree cant angle
  - Class 10K pad processing
  - PLF cleaning to VC-6
- ICESat requirements
  - Mass: 1030kg (max)
  - Two 61 pin PAF umbilicals
  - Three 24-in. diam. PLF doors
  - T-0 GN2 Purge (Teflon tubing under PLF blanket wrapped with 1.5” aluminized Kapton)
  - Spin at separation
  - Fairing Purge Tubing cleaned to level 100A
- CHIPSat requirements
  - Mass (Separating): 64.1 kg
  - One 37 pin connector
  - GN2 purge through liftoff
  - 9-in heavyweight clampband assembly & retention system
  - RHDPAF cleaning to VC-3
  - Electrical and purge bracket guards/shields



Mission Operations Overview

Cosmic Hot Interstellar Plasma Spectrometer

NASA/GSFC
Explorer Program



Awaiting Launch

NASA/GSFC
UNEX Missions

Launch
January 12, 2003

CHIPS LESSONS LEARNED

Lessons Learned – Formulation Phase

- Delays resulting from Launch Vehicle issues caused some beneficial things to happen:
  - NASA gave CHIPS a total of $405K (liened against Phases B-D) and 1 yr for Phase A.
  - During concept study period, CHIPS addressed weaknesses identified during TMCO.
  - Opportunity to better define long-lead items, perform detailed engineering of challenging structures & electronics

- Did not do FMECA/Fault Tree Analysis early on.

NASA/GSFC
UNEX Missions

Lessons Learned - Implementation

- Geography matters!
  - P.I. / instrument team, S/C contractor, environmental test facility, and launch site linked by modest drives & inexpensive flights; greatly facilitated exchanges of personnel and equipment
  - However, long term travel of key members should be considered a mission risk and thought through carefully.

Lessons Learned – Project Management

- Team Leadership wore multiple hats during the mission.
  - Org chart undermined Clear Roles and Responsibilities.
    - I&T Manager answered to the S/C Mgr, not to the PM
  - Difficult for single person to do multiple jobs well.
  - While intent and result was to keep costs low, there was real risk of missing launch
  - Level of effort required for project management of a small mission doesn't scale down as quickly as total cost
  - Small missions have tighter margins with little reserve for slips.
- The CHIPS success is largely due to a close partnership between the instrument team at Berkeley, the spacecraft team at SpaceDev, Inc., GSFC, SwRI, and Swales, and outstanding individual efforts from key engineers.

Lessons Learned – Project Management, Staffing Experience

- CHIPS proves that young professionals, with mentoring can lead a project successfully.
- Mix of experienced and more junior team members need not all be at same "level." Example: S/C was developed by relatively junior engineers but supported by experienced technician from SWRI.
- The challenges of the project and the "can-do" attitude encouraged the core workers at Berkeley and SpaceDev to stay with the project throughout its lifetime, and these young engineers are now strengthening projects such as JWST, THEMIS, and SNAP.

NASA/GSFC
UNEX Missions

Lessons Learned – Schedule

At Selection (Sep 98)

• CSR	3/15/99
• PDR/CAR	4/15/99
• Confirmation	5/1/99
• Begin Phase C/D	5/15/99
• DVR	9/15/99
• MRR	4/10/01
• Launch	5/14/01
• Phase E starts	6/15/01

At Selection:
7 Month Formulation Planned
25 Month Development Planned

At Completion:
27 Month Formulation
24.5 Month Development

At Completion

US Launch Policy Issue

Obtain Spacecraft Vendor

• CSR	9/1/99
• PDR/CAR	9/1/00
• Confirmation	12/1/00
• Begin Phase C/D	1/1/01
• DVR	4/17/01

Move from GPS Launch to ICESat

• Delta DVR	9/1/01
• Pre Environmental	8/15/02
• Pre-Ship/Mission Ops	10/6/02
• MRR	11/8/02
• Launch	1/12/03
• Phase E Starts	2/15/03

NASA/GSFC
UNEX Missions

Lessons Learned – Cost

What did CHIPS really Cost?

Original CHIPS Proposal Cost (9/98)	**<u>$9.8M (FY98$)</u>**
Code S Mission Cost Cap - Confirmation (12/00)	**<u>$16.0M (RY$)</u>**
• UCB Cost	$ 13.3M
• NIAT Cost Contribution	$ 2.7M
(plus a separate Code M Integration Contribution of $ 2.0 M)	
Code S Mission Total Cost - Launch (1/03)	**<u>$23.0M (RY$)</u>**
• UCB Development Cost(Phases A-D)	$ 14.0 M
• UCB Phase E costs	$ 2.0 M
• CATSAT Mini-DPAF (recovered Code S sunk cost)	$ 7.0 M

(Actual Code M Integration Contribution of $ 1.0 M)

Total NASA Cost for CHIPS **<u>$24.0M (RY$)</u>**

Lessons Learned – Contract Management

- CHIPS funded as a grant, not contract, to UCB
  - Significantly less burdensome to P.I. team
  - Less rigorous reporting requirements were offset by close supervision by GSFC and open lines of communication with P.I. and financial administrator
- Main subcontract for S/C structured as fixed-price but subject to evolving requirements, inevitably creating tensions [not unique to UNEX]
  - Small start-up nature of S/C provider made rigid linking of payments and deliverables difficult
  - Specifications/requirements were primarily high-level; should have included clearer definition of plans for technical approach and implementation

Lessons Learned – Reviews

- Through continuity in the membership of panels, NASA-led reviews became recognized as opportunities to strengthen the project through advice and experience, not forums to "beat up on" the project.

- The continuity of the review team from one review to the next was essential and helped the project from arguing the same old points over and over again.

- Review Team Members often helped the project team to address the concerns identified in the reviews.

NASA/GSFC
UNEX Missions

Lessons Learned – Reviews

At Selection (Per AO)

- Concept Study Review
- CAR, CRR & CR
- Design & Verification Review
- Mission Readiness Review

As Implemented

- Concept Study Review
- CAR, CRR, & CR
- Design & Verification Review
- Delta-DVR (from GPS to ICESat primary)
- S/C Bus Pre-Ship
- Pre-Environmental
- Pre-Ship Review
- Mission Operations Readiness
- Mission Readiness Review

Peer Reviews

TIMs: (Working Meetings)
RF/Com (8 Dec 99)
ACS (8 Dec 99)
Software (2 Sep 00)
SBC (10 Apr 00)
Ground Station (7 Jul 00)
Contamination control (21 Mar 01)
ADP review (13 Dec 02)

Peer Reviews: (Documented)
Detector Door (17 Feb 00)
SBC (4 Apr 00)
TDC (12 Apr 00)
Detector Mechanical (6 Jun 00)
Grounding (9 Jun 00)
DPU/HK (21 Jun 00)
FMECA (28 Jul 00)
Metering Structure (2 Aug 00)
LVPS (26 Sep 00)
Slit Towers (16 Oct 00)
ACS (22 Feb 01)
UCB Flight S/W (28 Feb 01)
Power System (13 Apr 01)
AEF review (27 Feb 02)
MOB Tiger Team (14 May 02)
Telecom (Jan 02)
Software (10 Jul 02)
ACS node requal. (03 Oct 02)

Lessons Learned – Misc. Technical Issues

- Developing MSPSP much more labor-intensive than expected
  - CHIPS team perceived different requirements from launch vehicle side (KSC/VAFB/Boeing) and from GSFC
  - Should identify "single point of contact" with strong experience in appropriate level of detailed needed for various analyses, etc.
- Internet-based mission operations extremely helpful; enabled flight-like operations environment to be created at any site (SpaceDev, UCB, KAFB, VAFB). Combined with fact that development engineers served as flight controllers, this led to significant mitigation of risk during early mission operations.
- 3 axis solar array placement allowed for screw-ups
- "Science Projects" (such as the original RF system) should be tied to firm cut off dates.
- Test, Test, Test helped CHIPS be successful

Observatory Testing

EMI/EMC (Battel Engineering) 1 August 2002	**Completed successfully**
Vibration testing AEF, 28-31 August 2002	
Random/Sine/Sine burst	**Completed successfully**
Magnetic dipole testing, 6 September 2002	**Completed successfully**
Pyro testing, 13-14 September 2002	**Completed successfully**
Thermal Vacuum Testing, 20-30 September 2002	**Completed successfully**

ACS node design flaw uncovered during TV testing

ACS node requalification, 1-6 October 2002 **Completed successfully**

System-level environmental testing went extremely smoothly in large part because of extensive prior testing at component and subsystem level. The presence of good test chambers at UCB made it technically and economically feasible for the team to carry out such tests during the schedule breaks that inevitably arise.

Lessons Learned – Testing
CHIPS Testing Phase Very Successful

NASA/GSFC
UNEX Missions

CHIPS Testing Comparison to other Small Missions (7/9/02)

ITEM	CHIPS	SNOE	TERRIERS	HETE-2 (1st launch campaign)	HETE-2 (2nd launch campaign)
Component Level Testing					
Thermal Vac Cycles/Time	4/100 hrs	3/36hrs		1 to 3 20 to 120 hrs	1 to 3 20 to 120 hrs
RF system (Tx/Rx)	272/1576hrs		0.2	~200 hrs	~200 hrs
ACS - Reaction Wheels	3400 hrs			0 to 20 hours	0 to 20 hours
Instrument(s)	TBD hrs		~ 150 hrs	40 to 360 hrs	40 to 560 hrs
S/C Bus - Flight config.					
Spacecraft w/o RF system	1973 hrs			~2000 hrs	~2000 hrs
Spacecraft w/ RF system	272 hrs	1240 hrs	3000 hrs	1200+ hrs	6000+ hrs
Observatory Level Testing					
Vibration Testing	*3 axis*	3 axis	3 axis	3 axis	3 axis
Thermal Vac Cycles/Time	**170 hrs**	**170 hrs**	**170 hrs**	**4 / 260 hrs**	**4 / 260 hrs****
0 faults w/ ACS Node fixe	*150 hrs*	500.0	350.0		700 hrs ***
Total Obsvtry. Run Time	***847****	**560.0**	**3000.0**	**1200.0**	**6000.0**

Notes:
* *Planned Observatory Testing for CHIPS*
** After launch scrub 8 cycles and 240 hours of additional thermal (not thermal-vac) testing performed
*** for final version of flight s/w; additional 1000 hrs run on flight spare processors.

Lessons Learned – Evolving Launch Vehicle

- Changes in key parameters (available volume, mass, orbit) led to less-than-optimal final configuration
  - 1/3 of instrument throughput lost to descope to fit GPS launch opportunity
  - ICESat opportunity arose on too tight a schedule to restore the descope
- Fundamental change in project scope (from providing an instrument for a commercial communications s/c to providing both an instrument and dedicated s/c) was only partially reflected in changes to P.I. team structure; team was always about one FTE short…

Lessons Learned – Launch Vehicle

- LV provider (Boeing) provided timely “deliverables list” to CHIPS, but detailed content of what was required was not always evident; there were some delays in getting information flowing in both directions
- Important errors in technical information
  - Clamp-band dynamic envelope
  - Predicted launch loads, esp. predictions for MECO event, were much too conservative – created redesign / rework, schedule delays, and loss of some flight hardware (broken optic) during testing

UNEX Lessons Learned Summary

NASA/GSFC
UNEX Missions

UNEX did not reached its potential as low-cost educational science missions
Due to primarily to the Cost and Availability of access to space.

<u>What has been successful regarding UNEX?</u>

- Facilitates science at the university level.
- Fills a science and technology niche between suborbital and orbital projects.
- Gives students hands-on instrument/spacecraft development experience.
- Promotes participation by minority universities.
- Provides entrée for small spacecraft builders into aerospace industry.

<u>What has not been successful regarding UNEX?</u>

- Low cost access to space did not become available.
- Principal Investigators (PI) were unsuccessful at arranging launch services by themselves.
- Universities didn't have adequate resources to meet SR&QA requirements

The future alternative concept for launching small university-class satellites on EELVs offers hope to maintain the science, technology and educational outreach components.

Backup charts

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

CHIPS RESIDUAL RISK ASSESSMENT

Issue	Residual Risk	Mitigation
Single String Design	High (medium-high)*	- Test Program was thorough and relatively trouble free - Redundant Reaction Wheel - Few mechanisms, few cycles, Only one mechanical SPF
Extensive Use of Commercial Parts - Uncertain radiation tolerance (SEE & TID) - Limited Alert searches and applicability	High (medium-high)	- Passed full environmental test program - Instrument has mostly Grade 2 parts (from prior UCB missions).

* (risk level for minimum mission)

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

CHIPS RESIDUAL RISK ASSESSMENT (Continued)

Issue	Residual Risk	Mitigation
Lack of Instrument Performance Headroom - Sensitivity is already slightly less than required - No inst. "performance" test at S/C level - "Hot spot" on detector	High (medium)	- Design has 6 spectrograph channels - Some degradation/failures can be overcome by more observing time
Late RF System Redesign	Medium (medium)	- Passed full environmental test program - Tx/Rx parts received additional GSFC scrutiny

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

CHIPS RESIDUAL RISK ASSESSMENT (Continued)

Issue	Residual Risk	Mitigation
VERY Small Team - Four person ops team - Vulnerable to loss of critical knowledge	Medium (low-medium)	- Plans being developed to manage credible personnel non-availability - Simple spacecraft, safe in tumble, most anomalies would not require urgent action
Process Control (Electrostatic discharge; Contamination; Other) - Virgin S/C contractor - Untried suppliers - University inst and I&T facility	Medium (low-medium)	- Successful integration and test results - Mostly trouble free Observatory environmental test program - No "evidence" of any degradation

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

CHIPS RESIDUAL RISK ASSESSMENT (Continued)

Issue	Residual Risk	Mitigation
Late ACS Node Problem - Discovered at S/C level environmental test - Non-standard repair configurations	Low (low)	- 299 hours failure free - Problem well understood and duplicated on other platforms - Full unit level environmental retest - Full circuit analysis for modified circuit
Instrument Alignment - No UV alignment and efficiency measurements after S/C integration - Instrument level vib test resulted in alignment problems	Low (low)	- Structural mods implemented - Retested and passed at instrument level - Some degradation/failures can be overcome by more observing time

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

OVERALL ASSESSMENT - HIGH RISK MISSION
- Medium-High for minimum mission

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT

CHIPSat Management Process Scores – November 2002

		UNEX	Typical Mission
1)	Technical Peer Reviews	7.5	5.4
2)	System Level Reviews	7.5	6.0
3)	Integration & Test Plan	7.1	5.1
4)	Mission Assurance	7.3	5.3
5)	Systems Management	7.0	5.3
6)	**Staffing & Experience**	**6.3**	5.3
7)	Integration & Test Results	7.4	6.1
8)	Operating Hours	7.5	6.8
9)	Tech Review Process Results	7.1	6.4
10)	Mission Sims/Training	7.1	5.6
11)	FMEA/FTA/PRA Process	7.3	5.1
12)	Mission Req'ts Verification Matrix	7.0	4.5
13)	**Single Point Failure Analysis**	**6.0**	4.5

CHIPSat MISSION READINESS REVIEW
INDEPENDENT READINESS ASSESSMENT
Thirteen Points Summary

Nominal: 7

6) Staffing & Experience **6.3**

- SpaceDev's first major contract, first flight hardware, first spacecraft
- New facility – All processes/practices/procedure new for CHIPSat
- Inexperienced teams – First spacecraft for both SpaceDev and PI; Many young key personnel – "thirty-something"
- VERY small team – Vulnerable to turnover and burnout

13) Single Point Failure Analysis **6.0**

- No formal SPF analysis performed
- No formal PRA performed
- Reliability estimates performed as part of FTA
- Primary justification for SPF's is cost, not technical

NASA/GSFC
UNEX Missions

Small Satellites – Report Card

	PI/Sponsor	Mission Lifetime	Post Mission Observations
PANSAT STS-95 (Oct 98)	U.S. Naval Academy	Still Operating	SUCCESS: operations after deployment; utilized the original "NUSAT" design for simplicity purposes since goal was educational tool for students
MightySat-1 STS-88 (Dec 98)	U.S. Air Force	11 months	SUCCESS: operations after deployment; users developing next spacecraft (FalconSat-2) with less complex subsystems; mission cost for MightySat approx. $5M
SAC-A STS-88 (Dec 98)	CONAE (Argentina)	10.5 months	SUCCESS: operations after deployment; onboard camera images successfully downloaded
Starshine-1 STS-96 (May 99)	Utah State/G. Moore (Code F/HQ)	8.5 months	PARTIAL SUCCESS: Ejection system deployed spacecraft "too smoothly"; was expecting small tip-off to achieve sparkle effect; spacecraft design that flew was descoped considerably from original concept due to lack of available expertise and resources to PI; 80% successful
Simplesat STS-105 (Aug 01)	GSFC/924 D. Skillman	5.5 months	FAILURE: Unable to establish communications with spacecraft; launched intentionally with dead batteries in effort to simplify STS safety process (a cost and effort reducing strategy that may have been catastrophic)
Starshine-2	Utah State/G.	On orbit	PARTIAL SUCCESS: N2 spin-up system failed due to improper